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FLEXURAL STRENGT, WORKABILITY, COMPRESSIVE STRENGTH AND SPLIT TENSILE STRENGTH ASSESSMENTS OF LIME STONE AGGREGATE CONCRETE

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ABSTRACT

Concrete is an artificial material in which the aggregates both fine and coarse are bonded together by the cement when mixed with water. The concrete has become so popular and indispensable because of its inherent in concrete brought a revolution in applications of concrete. Concrete has unlimited opportunities for innovative applications, design and construction techniques. Its great versatility and relative economy in filling wide range of needs has made it very competitive building material. At present there is depletion for both fine and coarse aggregates. The too much usage of good qualities of materials for concrete works is scares for future generation. Hence there is a search for other second grade and novel material to produce desired strength concrete. In this connection an attempt has been made, the use of lime stone aggregate (replacing of granite aggregate by lime stone aggregate in proportion of 20, 40, 60, 80 and 100%) for concrete works. Here an attempt made to use of lime stone aggregate in concrete to evaluate the workability, compressive strength, split tensile strength and flexure strengths

KEYWORDS: Cement, Lime Stone Aggregate, compression testing machine, split tensile machine and Flexural strength testing machine.

INTRODUCTION

Since concrete is the most important part in structural construction, the aggregate content should be in a form of good strength for structural purposes. Concrete is made up of aggregate, cement and water. Through this combination of Materials, three – quarter of the mix is governed by aggregate. The aggregate itself is categorized as fine and course aggregate.

In this study, the scope of research will be focused on the use of coarse aggregate using lime stone material. Before further discussion, it shall be better to have knowledge and clear understanding about the lime stone material and its properties and performances.
Lime stone is one of the aggregate to be used in concrete, other than thatare granite, basalt, Quartz, Gneiss, Gabbro, Sand stone, Felsiteetc.

Fig 1: Sample of Limestone Aggregate

In general granite aggregate is commonly used in industrial construction. Though IS 383-1970 code specifies the use of limestone and other aggregate for construction works, but it was very meager in reality. In this regard a ray of light was focused on use of lime stone aggregate for slabs elements. At present the generation of lime stone aggregate is discussed in detail. Tadpatri is town in Anantapur (Dist), this area is much potential for low limestone layered stone. The local people these layered stone is extracting and the same converting in to finished products, which are useful for flooring in dowelling houses.

These are made in required shape according the requirement of consumer. During the generation of required shape, a waste is generating and this is dumping in around the factories and besides of roads, this is due to lack of dumping area. In this town around 500 stone polishing machines are working per day. During working time of machine a waste is coming from each machine and these is dumping in around town. This disposal is also a big problem for polishing machine owners and for municipality authorities. After having a look over this scenario a thought came up and it leads to utilize the waste material in the concrete industry. In this connection it was decided that to utilize the waste as coarse aggregate after making the waste in 20 and 12 mm aggregate. For this crusher was used to obtain single graded material of 20 and 12 mm aggregate. After having this aggregate, an experimental work planned on two way slabs to know the behavior in punching aspect. A few photo graphs is presented below pertains to extraction of layered stone, converting into finished product and generation of waste during the operation stage. In continuation a crusher photograph was also presented below.

Fig 2: Generation of wasted during polishing

Fig 3: 20mm lime stone aggregate.

In construction industries, the use of aggregates is the most importance material in composition of concrete. Places having granite aggregate should have no problem in construction projects, but for places where the other type of aggregate is also available on par with granite, to curb the use of excessive granite material, in other words, to preserve the natural good material (granite) for future generation, it is necessary to use other available material in to some extent. Due to this reason this study should be carried out in the approaching method to overcome the problem as well as beneficial to local people.

ROCKS

Igneous rocks are formed from magma, which form below the surface, it ascends towards the surface, and crystallizes as solid rock on the surface of the earth

Sedimentary rocks are formed by the accumulation and compaction of fragments from pre-existing rocks originated from the erosion of organic materials such as dead plants, animals and other dissolved material. Sedimentation rocks are also formed by the process of settlement and saturation of those particular organics or minerals.

Metamorphic rocks are formed from pre-existing rocks, which undergo the increase in temperature or pressure or both. The original parent of the rocks changes its appearance, texture and mineral composition due to the process stimulated.

IGNEOUS ROCKS

In the formation of igneous rocks from magma, it is possible to describe three main types of classification. Magma consists of two distinctive layers, the bottom layer is the ultra-basic igneous rocks which comprise divine, olivine, calcium-rich plagioclase and augite to form an ultra-basic igneous rocks. This layer exists at high temperature. The second upper layer is the acids rock which comprises quartz, orthoclase, sodium-rich, plagioclase and micas

SEDIMENTATION ROCKS

There are four major groups of sedimentary rocks:-

a) Terrigenous sedimentary rocks that are formed by fragments derived from the breakdown of pre-existing rocks.

b) Chemical sedimentary rocks that are formed through the precipitation of salts dissolved in water.

c) Organic sedimentation rocks, which are formed from oil, coal and the skeletal remains of plants and animals.

d) Lime stones and dolomites, which are sedimentation, rocks consist of more than 50% carbonate including chemical, clastic and biological material. In this study, the rock which contains more carbonate is called carbonate rocks and limestone falls under this type of rocks. Therefore the fact of limestone is significant in this chapter to be further elaborated.

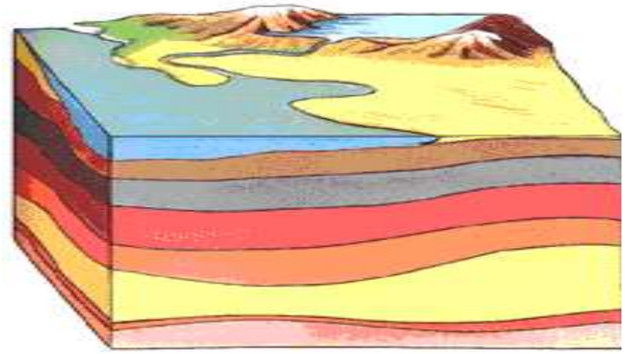

Fig 4: How sedimentation rock is formed

For millions of years, little pieces of the earth have been eroded by wind and water. These little bits of the earth are washed downs by streams and eventually settle to the bottom of the rivers, lakes, and oceans. Layer after layer of the eroded earth is deposited on top of each other. These layers are pressed down more and more through time, until the bottom layers slowly turn into rock.

Fig 5: Limestone Rock

Limestone is the most abundant of the non-clastic sedimentary rocks. The main source of limestone is the limy ooze formed in the ocean. The calcium carbonate can be precipitated from the ocean water or it can be formed from the sea creatures that secrete lime such as algae and coral. Chalk is another form of limestone that is made up of very small single-celled organisms. Chalk is usually white or gray. Limestone can easily be dissolved by acids. If some vinegar is dropped onto a limestone, it will fizz. Put a limestone rock into a plastic jar and cover it with vinegar. Cover the jar and watch the bubbling of the calcium carbonate and also the disintegration of the rock over a few days

OBJECTIVES OF TEST PROGRAM

1. To find the efficacy of the lime stone aggregate for civil constructions.
2. To know the fresh concrete properties of lime stone aggregate concrete.
3. To know the behavior of compressive and split tensile strength of lime stone aggregate.
4. To know the flexural behavior of lime stone aggregate concrete.
5. To know the failure modes under flexural loading.

To obtain the above objectives of the experimental work, the test programmer is planned as presented below.

Total 15 beam specimens are prepared. Three beams are with natural granite aggregate and other 12 beams are prepared with lime stone aggregate as replacement of granite aggregate in proration 20,40,60, 80 and 100%. The details of each category are described below.

DETAILS OF BEAM SPECIMENS

Size of beam specimen: 150X150X600mm

Mix proportion is: 1:1.91:3.17(for details refer

S.No.	Nomenclature	No. of specimens	Size of specimen	W / C ratio
1.	NC	3	150X150 X600mm	0.50
2.	LC-20	3		0.50
3.	LC-40	3		0.50
4.	LC-60	3		0.50
5.	LC-80	3		0.50
6.	LC-100	3		0.50

Apendix-1)

Water Cement ratio: 0.50

Number of specimens: 15No. (3-0%, 3- 20%, 3-40%, 3-60%,3-80% and 3-100%)

Table 1: The details of different beam specimens

Nomenclature.

NC

Where NC refers to Granite Aggregate Concrete, '0' refers to % replacement of Natural Coarse aggregate by Lime stone Concrete.

LC-20

Where LC refers to Lime stone Concrete and '20' refers to % replacement of granite aggregate by Lime stone aggregate

LC-40

Where LC refers to Lime stone Concrete and '40' refers to % replacement of granite aggregate by Lime stone aggregate

LC-60

Where LC refers to Lime stone Concrete and '60' refers to % replacement of granite aggregate by Lime stone aggregate

LC-80

Where LC refers to Lime stone Concrete and '80' refers to % replacement of granite aggregate by Lime stone aggregate

LC-100

Where LC refers to Lime stone Concrete and '100' refers to % replacement of granite aggregate by Lime stone aggregate

Based on the availability of equipment in the laboratory experimental work was conducted on cube, cylinders and beams so that it leads to evaluate compression, split and
flexural strengths. There is a need to study the microstructure of concrete by conducting the X-ray diffraction and SEM analysis. Due limitation of the equipments, it was confined to finding of above said strengths only.

MATERIAL USED IN THE INVESTIGATION

Lime stone aggregate

The raw material of Lime stone aggregate was obtained from stone polishing industries. The generated waste material was is not able to use as it is, as coarse aggregate in the concrete. So there is a need to develop as graded aggregate to use in concrete. To convert the waste as coarse aggregate the waste material was transported to crusher unit and made as 20 and 12.5 mm aggregate. This can be viewed in figure 4.1 and finished product (after crushed) depicted in figure 4.2. Two different sizes were obtained from the waste material, so as to use the material effectively. To obtain a reasonably good grading, 50% of the aggregate passing through 20 mm I.S. sieve and retained on 12.5mm I.S. Sieve and 50% of the aggregate passing through 12.5mm I.S. Sieve and retained on 10 mm I.S. Sieve is used. The specific gravity of combined aggregate was observed as 2.56.The physical properties for this aggregate are presented in table 4.5.The combined aggregate of granite and lime stone sieve analysis results are presented in table 4.6 from this .it is observed that the combined aggregate showed fineness modulus as 3.44

Table 2: Physical properties of lime stone Coarse Aggregate

S.No	Property	value
1	Specific Gravity	2.68
2	Bulk Density Loose State Compacted State	 12.13 kN/m^3 14.88 kN/m^3
3	Water Absorption	0.49%
4	Flakiness Index	16.22%
5	Elongation Index	23.33%
6	Crushing Value	12.53%
7	Impact Value	11.5%
8	Fineness Modulus	2.96

Table 3 Sieve Analysis of Coarse Aggregate

S. No	IS Sieve	Weight retained	% Weight retained	Cumulative % weight retained	% Passing
1	80 mm	0	0	0	100
2	63 mm	0	0	0	100
3	40 mm	0	0	0	100
4	20 mm	365	7.3	7.3	92.7
5	12.5mm	2525	50.5	57.8	42.2
6	10 mm	1100	22	79.8	20.2
7	4.75 μ	985	19.7	99.5	0.5
8	2.36	25	0.5	100	0
Total =344.4 Fineness Modules = 3.44					

Fig 6: Crushing of Lime stone Aggregate in crusher.

Water:
Potable fresh water available from local sources was used for mixing and curing of LSA and NAC slabs.

Casting:
The cubes were cast in steel moulds of inner dimensions of 150 x 150 x 150mm, the cylinders were cast in steel moulds of inner dimensions as 150mm diameter and 300mm height and finally, the flexural beams were cast in steel moulds and timber moulds with inner dimensions of 150 x 150 x 150mm.

All the materials are weighed as per mix design and kept a side separately. The cement, sand, coarse aggregate and lime stone aggregate were mixed thoroughly till to reach uniformity to the concrete mix.

For all test specimens, moulds were kept on table vibrator and the concrete was poured into the moulds and the compaction was adopted by mechanical vibrator. The moulds were removed after twenty four hours and the specimens were demoulded
and were exposed to water bath for 28 days in curing pond. This can be viewed in figure 4.3. After curing the specimens in water for a period of 28 days, the specimens were taken out and allow drying under shade. Three cubes, three cylinders and three flexural beams were cast for each mix.

Fig 7: Lime stone Aggregate.

Fig 8: View of the Specimens cured in the Water Tank

Workability
All the mixes were evaluated for workability during fresh concrete stage by means compaction factor test. The description of this test is presented below.

Compaction factor test:
The apparatus for conducting compaction factor test is depicted in Figure: 4.4. The compaction factor test apparatus consists of two hoppers, each in the shape of frustum of a cone and one cylinder. The upper hopper is filled with concrete this being placed gently so that no work is done on the concrete at this stage to produce compaction. The second hopper is smaller than the upper one and is therefore filled to overflowing. The concrete is allowed to fall in to the lower hopper by opening the trap door and then into the cylindrical mould placed at the bottom. Excess concrete across the top of the cylindrical mould is cut and the net weight of the concrete in cylinder is determined. This gives the weight of partially compacted concrete. Then the cylindrical mould is filled with concrete and compaction was done by tamping rod.. The fully compacted weight is then determined and compaction factor (C.F) is calculated by using the formula given below. The obtained values are presented in the next chapter .i.e. analysis and discursion of results.

$$C.F. = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

Fig 9: View of the test setup for Compaction Factor

Test Setup and Testing:

Cube compressive strength test:

The test set up for conducting cube compressive strength test is depicted in Figure: 10. Compression test on cubes is conducted with 2000kN capacity compression testing machine. The machine has a least count of 1kN. The cube was placed in the compression-testing machine and the load on the cube is applied at a constant rate till to failure of the specimen and the corresponding load is noted as ultimate load. Then cube compressive strength of the concrete mix is then computed by using stand formula. (This test has been carried out on cube specimens at 28 days) and the obtained values are presented.

Fig 10: Compression Testing Machine (CTM)

Split tensile strength:

This test is conducted with compression testing machine and it can be viewed in figure: 11. The cylinder is placed on the bottom compression plate of the testing machine and is aligned such that the center lines marked on the ends of the specimen are vertical. Then the top compression plate is brought into contact at the top of the cylinder. The load is applied at uniform rate, until the cylinder fails and same load is taken in to account as ultimate load. From this load, the splitting tensile strength is calculated for each specimen by stand formula. The results are presented.

Fig 11: Compression Testing Machine (CTM)

Flexural strength test:

The loading arrangement to test the beam specimens for flexure is shown in Figure: 4.8. The test is conducted on a loading frame. The beam element is simply supported on two rollers of 4.5 cm diameter over a span of 450 mm. The element is checked for its alignment longitudinally and adjusted if necessary. Required packing is provided using rubber material. Care was taken to ensure that the two loading points were at the same level. The loading was applied on the specimen through hydraulic jacks and was measured using a 15 tones pre-calibrated proving ring. The load is transmitted to the beam element through the I-section and two 16mm diameter rods spaced at a distance of 150 mm. For each increment of loading, the deflections at the center of span are recorded using dial gauges. Continuous observations were made and the cracks were identified with the help of magnifying glass. Well before the ultimate stage, the deflect meters were removed and the process of load application was continued till to continued total failure and at this stage the load is recorded as ultimate load. The flexural strength of the beam specimens for each mix is computed and the same values are presented in next chapter

Figure 11: Flexural Strength test setup

DISCUSSION OF TEST RESULTS

Influence of lime stone aggregate on workability

The workability of mixes have been measured by Compaction factor test. The values of compaction factors results are presented in Table 3 and figure 12.From this it is observed that the compaction factor increase with increase in the % of lime stone aggregate in the concrete mix. Hankfi Binci et.al (2008) has been also reported same type of result for marble concrete. The increase of workability may be due to lower water absorption and smooth texture surface of lime stone aggregate than the granite aggregate.

Table 3: Workability of concrete.

S.No	Nomenclature	Compaction Factor(CF)
1.	NC	0.768
2.	LC 20	0.772
3.	LC 40	0.786
4.	LC 60	0.811
5.	LC 80	0.875
6.	LC 100	0.912

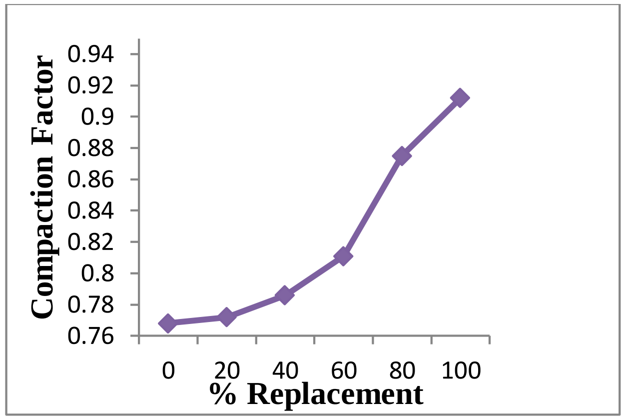

Fig 12: Compaction Factor vs. % Replacement

Influence of lime stone aggregate on compressive strength.

The compressive strengths for all mixes are presented in table 4 and Figures 13. From this, it can be observed that the 28 days compressive strength decrease with the increase in the percentage of lime stone up to 100%. For 20% replacement of lime stone aggregate there is decrease in cube compressive strength by 9.62% over granite aggregate concrete. For 40% replacement level, the compressive strength has decrease by 27.05% when compared with reference concrete. For 60% replacement level, the compressive strength has decrease by 25.97% when compared with reference concrete. For 80% replacement level, the compressive strength has decrease by 28.46% when compared with reference concrete. At 100% replacement of lime stone, the compressive strength has decreased by 42.35% over granite aggregate concrete. This type of observation was observed by Hanfi Binici et.al (2008) for marble concrete. But Hebhoub et.al (2011) reported in different way for marble concrete. They reported that, at 80% replacement level the strength was enhanced when compared with other replacements and at 100% replacement level there was decrease in compressive strength. Whereas from present experimental work it is observed that there is continuously decrease in compressive strengths as percentage of lime stone aggregate increases in concrete mix. This may be due to different surface texture of aggregates.

Table 4: Compressive Strength for lime stone aggregate concrete

S.No	Nomenclature	Ultimate Stress(N/mm2)	Average stress(N/mm2)	% Decrease in compressive strength
1.	NC 1	32.59	32.47	-
	NC 2	30.72		
	NC 3	34.09		
2.	LC 1-20	30.13	29.56	9.62
	LC 2-20	28.96		
	LC 3-20	29.58		
3	LC 1-40	25.15	25.08	25.05
	LC 2-40	25.56		
	LC 3-40	24.52		
4	LC 1-60	22.50	23.50	27.97
	LC 2-60	23.81		
	LC 3-60	24.19		
5	LC 1-80	22.39	22.54	28.46
	LC 2-80	23.27		
	LC 3-80	21.95		
6	LC 1-100	17.37	18.23	42.35
	LC 2-100	18.75		
	LC 3-100	18.57		

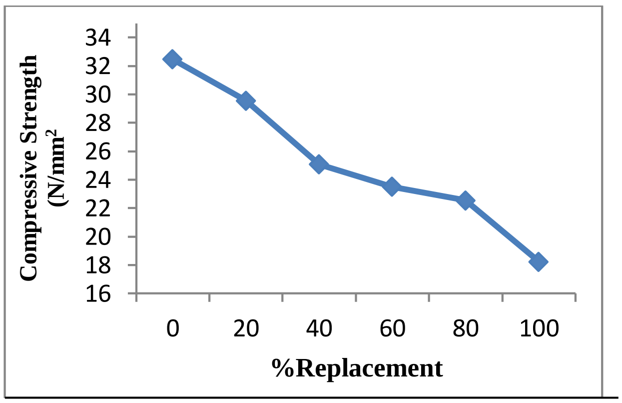

Fig 13: Compressive Strength vs. % Lime stone aggregate

Influence of lime stone aggregate on spilt tensile strength:

The variation of 28 days Split tensile strength of lime stone mixes is presented in table 5 and Figures 14. From these it is observed that the split tensile strength decrease with the increase in the percentage of lime stone up to 100%. For 20% of lime stone there is decease in split tensile strength by 21.64% over the granite aggregate concrete. For 40% of lime stone there is decease in split tensile strength by 31.34% over the granite aggregate concrete. For 60% of lime stone there is decease in split tensile strength by 35.65% over the granite aggregate concrete. For 80% and 100%, the split tensile strength has decreased by 50.62% and 62.23% respectively over granite aggregate concrete (reference mix). Hebhoub et.al (2011) reported in different way for marble concrete. They reported that, at 80% replacement level the strength was enhanced when compared with other replacements. Hanfi Binici et.al (2008) reported the split tensile strengths for marble concrete. They observed that there is a marginal increase in split tensile strengths as percentage of marble aggregate increases in concrete mix. But the present experimental results showed reverse trend i.e., there is decrease trend as lime stone aggregate content increases in concrete.

Table 5: Split Tensile Strength

S.No	Nomenclature	Ultimate Stress(N/mm^2)	Average stress(N/mm^2)	% Decrease in split tensile strength
1.	NC 1	7.63	7.75	-
	NC 2	7.79		
	NC 3	7.82		
2.	LC 1-20	6.14	6.08	21.64
	LC 2-20	6.07		
	LC 3-20	6.02		
3	LC 1-40	5.12	5.21	31.34
	LC 2-40	5.26		
	LC 3-40	5.24		
4	LC 1-80	4.95	4.98	35.65
	LC 2-80	5.02		
	LC 3-80	4.96		
5	LC 1-75	3.71	3.56	50.62
	LC 2-75	3.52		
	LC 3-75	3.45		
6	LC 1-100	2.80	2.96	61.97
	LC 2-100	2.98		
	LC 3-100	3.10		

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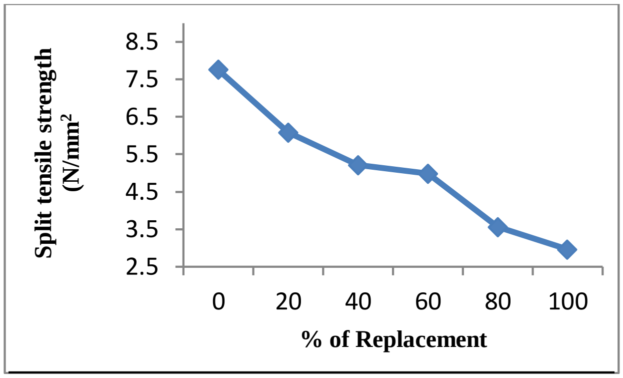

Fig 14: Split Tensile Strength vs % Lime stone aggregate

Influence of lime stone aggregate in Flexural strength

The flexural strength of lime stone aggregate concrete results are presented in table 7 and Figures 15. From this it is observed that the 28 days flexural strength decrease with the increase in the percentage of lime stone aggregate up to 100%. For 20% replacement there is decease in flexural strength by 12.51% w.r.t. reference mix. For 40% replacement there is decease in flexural strength by 14.18% w.r.t. reference mix For 60% replacement there is decease in flexural strength by 21.26% w.r.t. reference mix. At 80% and 100%, the flexural strength has decrease by 30.68% and 42.43% respectively with respect reference mix (granite aggregate concrete). Hanfi Binici et.al (2008) reported the flexural strengths for marble concrete. Their observation in flexural strength is very low significance over control specimens. The granite aggregate showed a lesser value compared with marble concrete. But form the present investigation it is observed that as lime stone aggregate increases there is decrease in flexural strength when compared with granite aggregate. This simple test does not measure the bond strength at aggregate interface but it is possible to compare the effect of the aggregate substitution.

Table 7: Flexural Strength

S.No	Nomenclature	Ultimate Stress(N/mm2)	Average stress(N/mm2)	% Decrease in split tensile strength
1.	NC 1	5.42	4.94	-
	NC 2	4.25		
	NC 3	5.16		
2.	LC 1-20	4.67	4.62	12.51
	LC 2-20	4.56		
	LC 4-20	4.62		
3	LC 1-40	4.43	4.52	14.18
	LC 2-40	4.60		
	LC 3-40	4.54		
4	LC 1-80	4.30	4.33	21.26
	LC 2-80	4.42		
	LC 3-80	4.28		
5	LC 1-75	3.47	3.44	30.68
	LC 2-75	3.36		
	LC 3-75	3.49		
6	LC 1-100	3.02	3.05	42.43
	LC 2-100	3.16		
	LC 3-100	2.98		

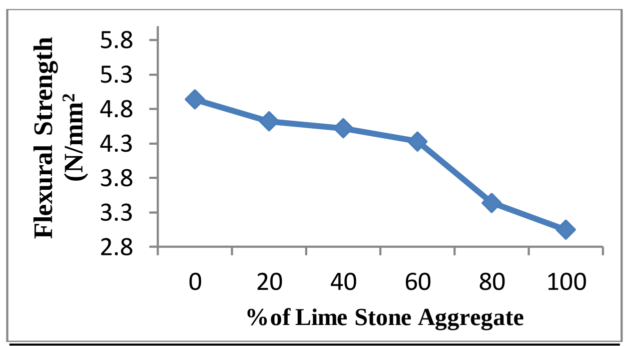

Fig 15: Flexural strength vs. % of lime stone aggregate.

Flexural failure patterns for tested specimens:

Some of the tested beam specimens are pressed in figure 16. From the figure 16 all these it is observed that the crack was appearing in the middle part of the beam specimen. The crack propagation is 90 degrees to axis of beam, this implies that the failure is due be pure bending.

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Fig 16: Tested specimens of beam (a)

Fig 17: Tested specimens of beam (b)

Fig 18: Tested specimens of beam (c)

Efficacy of lime stone aggregate to concrete works:

The effectiveness of lime stone aggregate of concrete works can be observed in Fig 19. The design grade of concrete is M20.The concrete with granite aggregate showed the compressive strength of 32.69. The replacement of lime stone aggregate concrete with 25, 50 and 75% levels showed the compressive strength of 29.24, 24.20 and 22.39 N/mm2 respectively. But the 100% incorporation level showed the compressive strength is about 18.82 N/mm2. From these observations is came to implies that the design strength obtained up to 90% replacement level, beyond this the concrete does not exhibit the design strength. The inference of this is, lime stone aggregate can be used upto 90% level for concrete works. This can be observed in Figure: 5.6. However to ascertain this statement, we need a lot of research work. The present research work gives an indication to extend the research work in this arena.

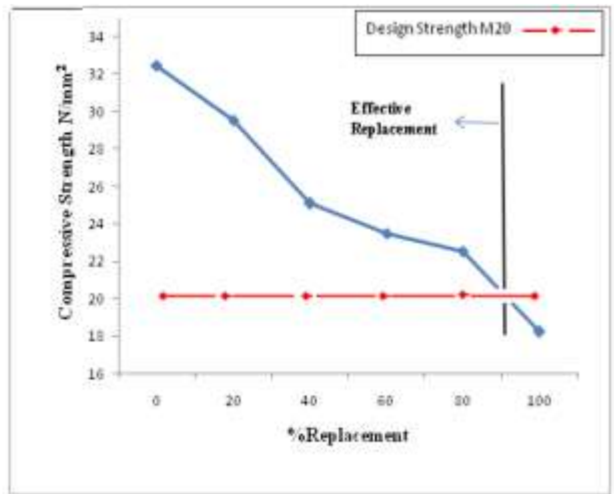

Fig 19: Effective replacement of lime stone aggregate

CONCLUSIONS

The following conclusions may be drawn from the present experimental work

1. The workability for limestone aggregate is increases with compared with granite aggregate concrete.
2. The compressive strengths were decreased with increase the lime stone aggregate in the concrete mix.
3. The split tensile strengths were decreased for lime stone aggregate concrete compared with granite aggregate concrete.
4. The flexural strength was marginally affected for lime stone aggregate concrete.
5. The incorporation of lime stone upto 75% is beneficial for the concrete works.
6. The failure modes are similar for both lime stone and granite aggregate concrete.
7. The use of lime stone aggregate for concrete works is demonstrated in compression, split and flexural strengths
8. This study could enlighten the local peoples to use of limestone aggregate for concrete works (minor works at initial stages).

RECOMMENDATIONS FOR FUTURE INVESTIGATIONS

1. The studies can be conducted to know the performance under impact and torsion loading
2. Studies can be conducted by incorporation of steel fibres
3. Mathematical / Empirical models can be developed for the lime stone reinforced concrete.
4. Durability studies such as resistance to Sulphate attack, Acid resistance etc., can be carried out on lime stone reinforced concrete.

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